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RESEARCH DEPARTMENT



REPORT

**A p.c.m. sound-in-syncs
distribution system:
combination and separation of
sound and video signals**

No. 1969/52

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**A P.C.M. SOUND-IN-SYNCS DISTRIBUTION SYSTEM:
COMBINATION AND SEPARATION OF SOUND AND VIDEO SIGNALS**

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(EL-34)

A P.C.M. SOUND-IN-SYNCS DISTRIBUTION SYSTEM: COMBINATION AND SEPARATION OF SOUND AND VIDEO SIGNALS

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A P.C.M. SOUND-IN-SYNCS DISTRIBUTION SYSTEM: COMBINATION AND SEPARATION OF SOUND AND VIDEO SIGNALS

SUMMARY

This report, one of a series of four, gives the basic requirements and simple descriptions of experimental equipment for the combination and separation of sound and video signals as used in the 'sound-in-syncs' system for conveying a sound signal together with a video signal along a video link. Performance figures for the equipment are given and from the results of field trials, some modifications are detailed.

1. INTRODUCTION

The 'sound-in-syncs' system is intended for the distribution of 625-line video and sound signals between studio centres and transmitters. The sound signal is converted into pulse-code modulation and the coded digits are inserted into the line synchronizing pulse of the video signal giving a single combined sound and video signal. The two components are separated at the transmitter and radiated in the usual manner.

The fundamental concepts of the sound-in-syncs system are described elsewhere,^{1,2} and a general description of the experimental system is given in the first report of the present series³ as well as in other published papers.^{4,5} This report deals with the experimental equipment for the combination and separation of the sound and video signals, while details of other parts of the experimental equipment are described in companion reports.^{6,7}

Following field trials to establish the operational feasibility of the system, some modifications were devised to increase the protection given to the sound signal against faults occurring in the vision signal. The essential features of these modifications, together with some suggestions for improving the performance of other parts of the equipment, are outlined at the end of the report.

2. BASIC REQUIREMENTS

The sound-in-syncs system can be considered as a time-division multiplex process in which the distribution link is available to the video signal for the major part of the line period and the sound signal for the remaining time. It has been shown¹ that the most suitable placing for the sound signal is in the line synchronizing period. With these two concepts, and also experience gained from earlier equipment, the following basic requirements can be formulated:—

- (a) There should be minimal interference between sound and video signals when combined.
- (b) The transmission of the sound signal should be independent of the state of the video signal — i.e. video content, picture/sync ratio, overall vision amplitude — and should not be interrupted in the event of video failure.
- (c) The video signal should be independent of the nature of the added digital sound signal — i.e. amplitude of pulses, number of pulses, and time occupied by the complete pulse group.
- (d) To prevent distortion of the video signal any processing in the combiner and separator should be kept to a minimum.
- (e) The equalising pulses occurring at line rate during the field block must be widened to accommodate the sound signal and restored to normal width after removal of the sound signal.
- (f) The leading edge of the line synchronizing pulses and the phase of the colour subcarrier burst should be accurately preserved throughout the system.
- (g) The system should not demand for its proper operation any increase in standard of performance of the distribution link over that normally required for the vision signal.
- (h) The system should continue to operate satisfactorily under conditions of distribution link distortion equivalent to 2 United Kingdom reference chains⁸ in tandem under a 'maintenance condition'* with some additional margin of safety against failure of the p.c.m. sound signal through digit errors. (The safety margin will be quoted as the amount of additional white noise that can be added before digit errors occur.)

* A distribution link under 'maintenance conditions' has performance figures slightly below the normally accepted lower limits. This condition is allowed while maintenance is carried out on the link.

- (i) The input and output terminals should accept and deliver signals at standard levels and impedance.
- (j) The system should operate satisfactorily during timing discontinuities that may exist in the video signal — e.g. switches between two non-synchronous sources.
- (k) The satisfactory transmission of the combined signal should not demand extensive modifications to the existing link and switching centre equipment.

3. SIGNAL PARAMETERS

3.1. Time Available for Sound Pulse Group

The specified duration of the line synchronizing period is $4.7 \pm 0.1 \mu\text{s}$ with edge rise times of $250 \pm 50\text{ns}$. Allowing some additional tolerance for signals not meeting the specification the minimum duration of the bottom of sync. pulses was therefore assumed to be $4.2 \mu\text{s}$.

To minimise crosstalk resulting from phase distortion on the distribution link, guard spaces are left between sync. edges and the start and finish of the sound pulse group. The guard spaces also ensure that the waveform dwells for a short time at bottom of sync. level, which simplifies the process of sync pulse separation from a combined signal. A suitable guard space is 200 ns thus giving a maximum time available for the sound pulses of $3.8 \mu\text{s}$.

In practice, the process of sync pulse separation and formation of the sound pulse group introduced in unavoidable delay of approx. 400 ns and thus the inclusion of additional delay to form a guard space was unnecessary.

The widening of the equalising pulses to provide the $3.8 \mu\text{s}$ required by the sound pulse group is achieved automatically in the operation of gating in the sound pulses.

3.2. Form and Number of Sound Pulses

The spectrum of the sound pulses must be completely contained within the 5.5 MHz video bandwidth, and their shape must be such as to avoid crosstalk between adjacent pulses. The pulses must also be as narrow as possible so that the maximum number can be accommodated in a $3.8 \mu\text{s}$ interval.

The raised cosine or $2T$ pulse fulfils these conditions and has the added advantage that this same pulse is used for measuring video link performance. The ability of a link to convey the sound-in-vision signal can therefore be deduced from standard video measurements.

The $2T$ pulses can be overlapped, without mutual interference, if the spacing between pulses is not less than the half-height width.¹ At this spacing the epoch of one pulse occurs at the zero of adjacent pulses and there is no loss of modulation or eye height.¹

In another part of the sending terminal equipment⁶ the analogue-to-digital converter (a.d.c.) samples the sound

signal twice per television line and each sample is converted to a 10-bit binary word. To obtain the greatest noise immunity the coded sound digits are inserted into the line sync. in the binary form with a peak amplitude equal to the peak white level of the vision signal. One additional $2T$ pulse is added preceding the sound pulses and is used in the separation process as a timing reference for sound pulse detection. The marker pulse ensures accurate detection in the event of link phase distortion since it suffers distortion in the same manner as the coded sound pulses; this would not necessarily be the case if the leading edge of syncs were used as a timing reference for pulse detection.

The number of pulses inserted into the video signal is $2 \times (10\text{-bit binary word})$ plus one marker pulse, giving a total of 21.

The time t_s required, in a system of bandwidth $1/T$, to accommodate n pulses spaced at intervals S , is given by:—

$$t_s = (n - 1)S + 4T$$

In the present case, $2T = 182\text{ ns}$, $n = 21$ and $t_s = 3.8 \mu\text{s}$, whence $S = 172\text{ ns}$; it can be shown¹ that the corresponding eye height is 91% giving a loss of approximately 1 dB in noise immunity.

Fig. 1 is a photograph of a sound-in-syncs waveform illustrating the position of the sound pulse group within the line synchronizing period. The sound signal appearing in the figure is a superposition of several different pulse patterns, so that the eye pattern is clearly visible.

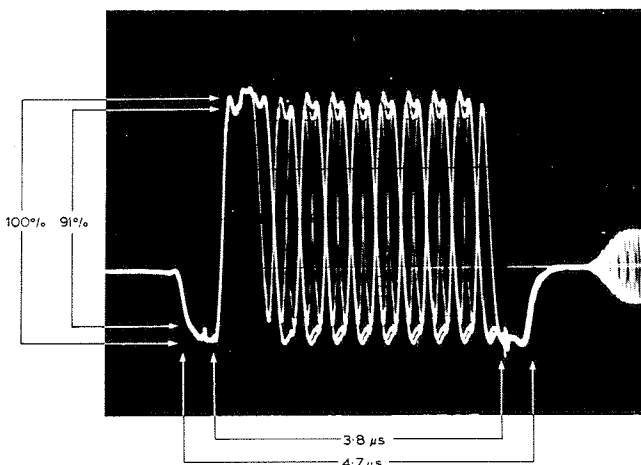


Fig. 1 - Sound pulse group inserted into line sync pulse

3.3. Distribution of Sound Pulses Within the Line Synchronizing Period

If the phase and/or the amplitude of mid-frequency components is not correctly preserved in the distribution link, parts of the video waveform can be distorted. The distortion takes the form of a disturbance in the video signal which is a function of the mean level of the preceding signal. In particular the level of the post-line-synchronizing blanking period, or back porch, can be a function of the mean level of the synchronizing pulse.

For a sound-in-syncs signal the mean level of the sync period will vary according to the pattern of the sound pulse group, and under conditions of distortion the level of the back porch will vary. Equipment using the back porch for black-level reference will then introduce errors, the subjective effect of which is similar to that observed on a mal-adjusted television receiver displaying sound on vision.

If the two 10-bit binary words from the a.d.c. are inserted directly into the video waveform, the mean level of the sync pulse can vary, according to the code, from bottom of sync level for all zeros to video peak white level for all ones. To reduce this variation of mean level, advantage is taken of the fact that substantial changes in binary words representing consecutive samples of the sound signal are rare, and that changes that do occur are most likely to affect the least significant digits. First, one of the two digit words is complemented — that is, ones are exchanged for zeros and vice versa. Secondly the two digit words are interleaved such that corresponding digits from each word are adjacent, and finally the least significant digits are inserted first so that digits which are subject to the most frequent changes are farthest in time from the back porch.

A single sound pulse group has typically the form shown in Fig. 2, which was photographed for a fixed digit word pattern, corresponding to a D.C. sound input signal.

The artifices described above significantly reduce, but do not completely remove, the perturbations of the back porch. The sound-in-syncs signal is therefore stabilised by a clamp acting as close to the end of line blanking as waveform tolerances allow, where perturbations are smaller. The clamp has a time-constant of about 10 television lines. A new back porch is then inserted at a level determined by the stabilising action.

The above techniques are completely effective for link distortions at frequencies greater than 80 kHz and less than 3 kHz. For distortions at frequencies around 15 kHz, perturbations can extend into the active video signal.

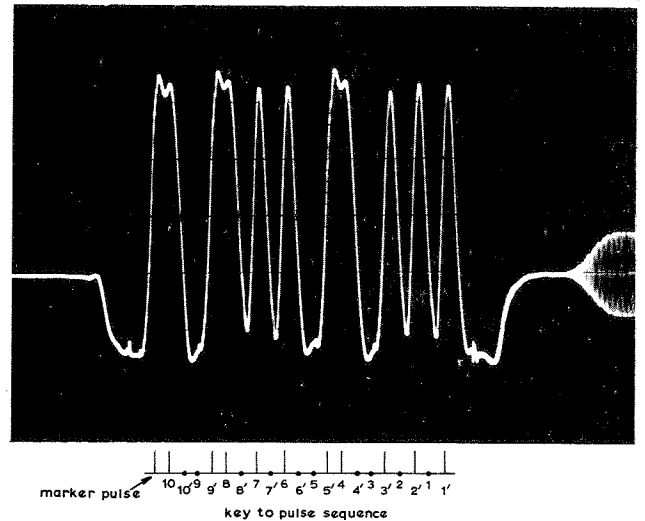


Fig. 2 - Sound pulse group inserted into the line sync waveform — DC input to sound coder

The illustration shows the interleaving and complementing process applied to two identical digital words described by digits 1 to 10 and 1' and 10' respectively

Although back porch re-insertion prevents subsequent errors the disturbance to the active video signal cannot be removed; however, it should be noted that the effect does not become annoying until the distortion has exceeded that specified by 2 UK Reference chains in tandem.

4. DESCRIPTION OF EQUIPMENT

4.1. Combiner

4.1.1. General

A block diagram of the Combiner is shown in Fig. 3 which illustrates the essential features of the equipment.

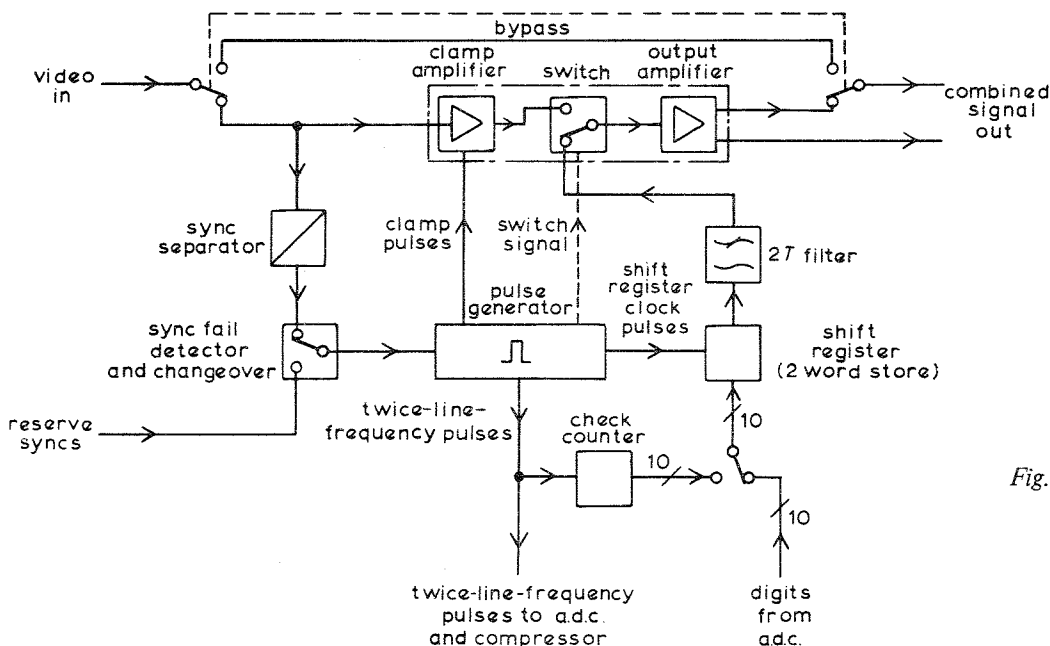


Fig. 3 - Block diagram of combiner

Synchronizing pulses are separated from the incoming video signal and used for triggering all processes that occur during the following line time. Each line sync. pulse supplies pulses at twice line frequency to the a.d.c. and compressor which are in other parts of the equipment. The two 10-bit binary words received from the a.d.c. are stored in the Combiner to be read out in the correct order and form for gating into the next line sync. period of the video signal, which has been stabilised in a clamp amplifier.

A sync fail detector automatically changes over to a reserve feed of sync pulses which maintains the sound signal in the event of a failure of the video signal.

A 10-stage binary check counter generates a digital pattern equivalent to a ramp sound signal, and is used for verifying the correct operation of the equipment. The counter can be stopped in any position thereby providing fixed digital words for test purposes.

4.1.2. Input Processing

The input video signal is normally a distortion-free output from a studio centre, and a standard sync. separator unit is therefore employed. The delay of the separated syncs is kept low, approx. 100 ns, ensuring that the sound pulse group is inserted in the correct position within the line-synchronizing period.

A time delay of 4 television lines is incorporated in the sync-fail detection circuit to prevent the changeover to reserve syncs taking place during small discontinuities in the waveform that may occur during momentary source faults. When the incoming video signal fails no field syncs appear in the output combined waveform. At first this omission, which would afford an indication that vision had failed, was thought to be acceptable. However, it was subsequently established that when line sync pulses only are present, certain unattended transmitters will be automatically switched off, and it is therefore desirable that future equipment should maintain the composite waveform even under fault conditions.

The time taken to complete the sound coding sequence initiated by each sync pulse is 60 μ s, and an inhibiting circuit is incorporated in the pulse generator to prevent retriggering until 62 μ s after the preceding sync. pulse. This measure prevents false operation which might otherwise be caused by the half-line pulses of the field period and also by cuts between non-synchronous video sources. Noise spikes or transitory input conditions giving rise to erroneous sync separation may cause a sound pulse group to be inserted in the wrong position if these faults occur after a 62 μ s interval; however, similar timing circuits in the separator equipment detect these sound groups satisfactorily.

4.1.3. Sound Pulse Group Generation

The 10-bit digital words presented during each half-line period by the a.d.c. or check counter are stored in alternate positions of 20 stages of a 21-stage shift register; the additional stage is provided for storing the marker

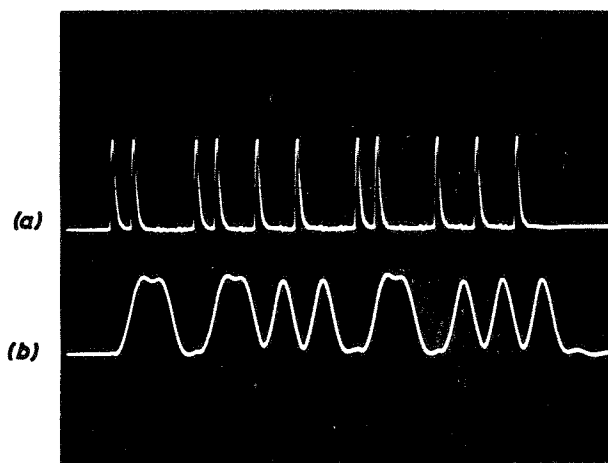


Fig. 4 - Sound pulse group

(a) Sampled output of combiner shift register
(b) Output of 2T filter

pulse. Complementing of alternate words is achieved by appropriate connection within the shift register. During the next sync pulse the register is read out serially at a 172 ns clock period, sampled at the same rate to convert the box-car output to pulses and finally filtered in a 2T pulse network.

Fig. 4 is a photograph of the sampled output of the shift register, and of the output of the 2T filter.

4.1.4. Sound and Vision Combination

The video signal is back porch stabilised in a feed-back clamp amplifier and the sound pulse group gated by a diode switch into the video signal at normal sync pulse level, i.e. 0.3 volt below black level. By gating the pulse group with reference to black level the insertion is made independent of sync pulse amplitude even in the event of complete video failure. In addition, the same reference level is easily found during the subsequent separation process at the receiving terminal, and the most important part of the pulse group, i.e. the centre of the eye, is situated in a part of the waveform that suffers least from any non-linear distortion that may be introduced by the distribution link.

4.1.5. Additional Facilities

A video by-pass facility was provided for use in case of equipment failure. Fault-finding is possible in the by-pass state since the equipment will continue to operate on reserve syncs. The by-pass is designed to fail safe in the event of power failure.

In its experimental form, the combiner equipment, illustrated in Fig. 5, occupies one 19 in. panel.

4.2. Separator

4.2.1. General

A block diagram of the separator is shown in Fig. 6 which illustrates the essential features of the equipment.

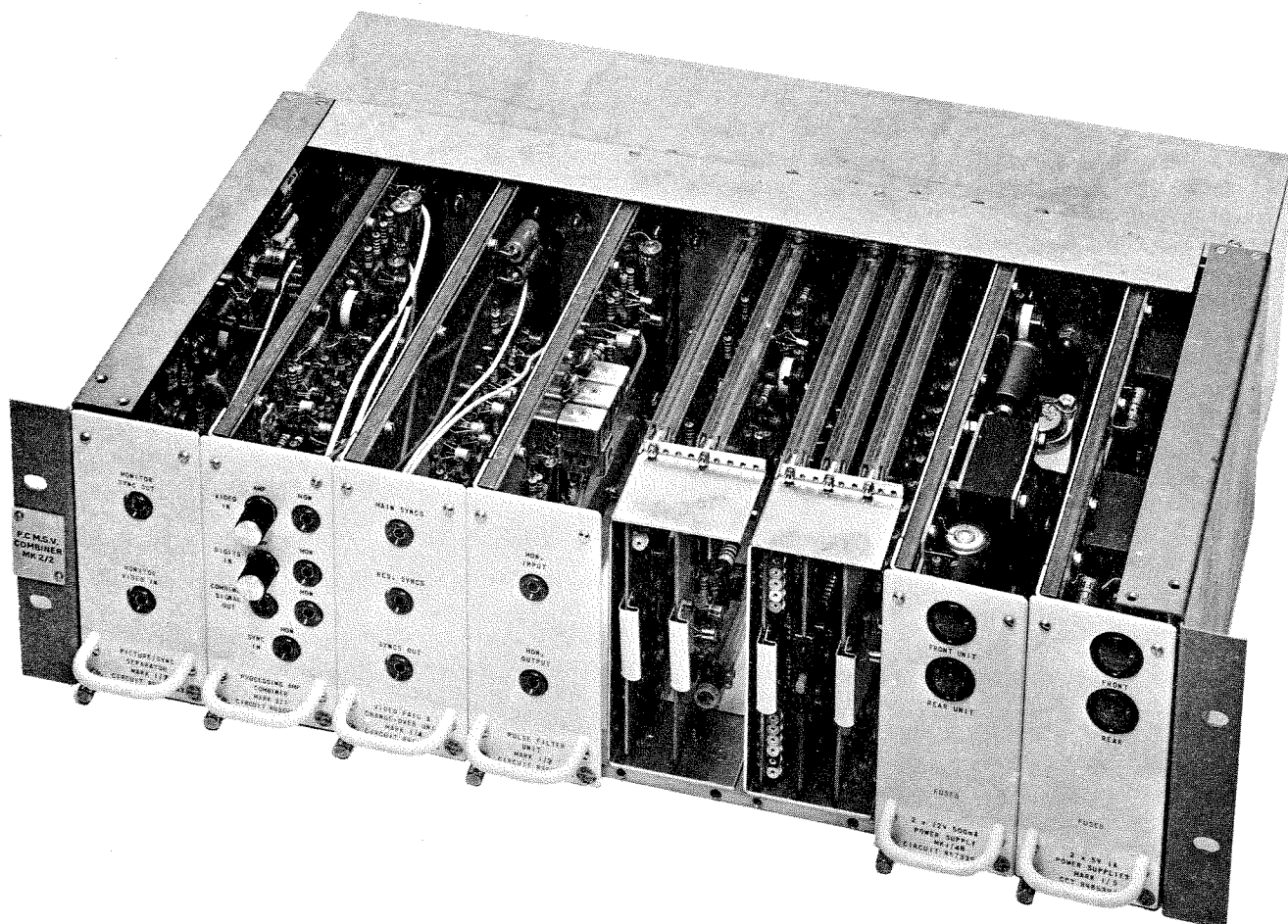


Fig. 5 - Combiner

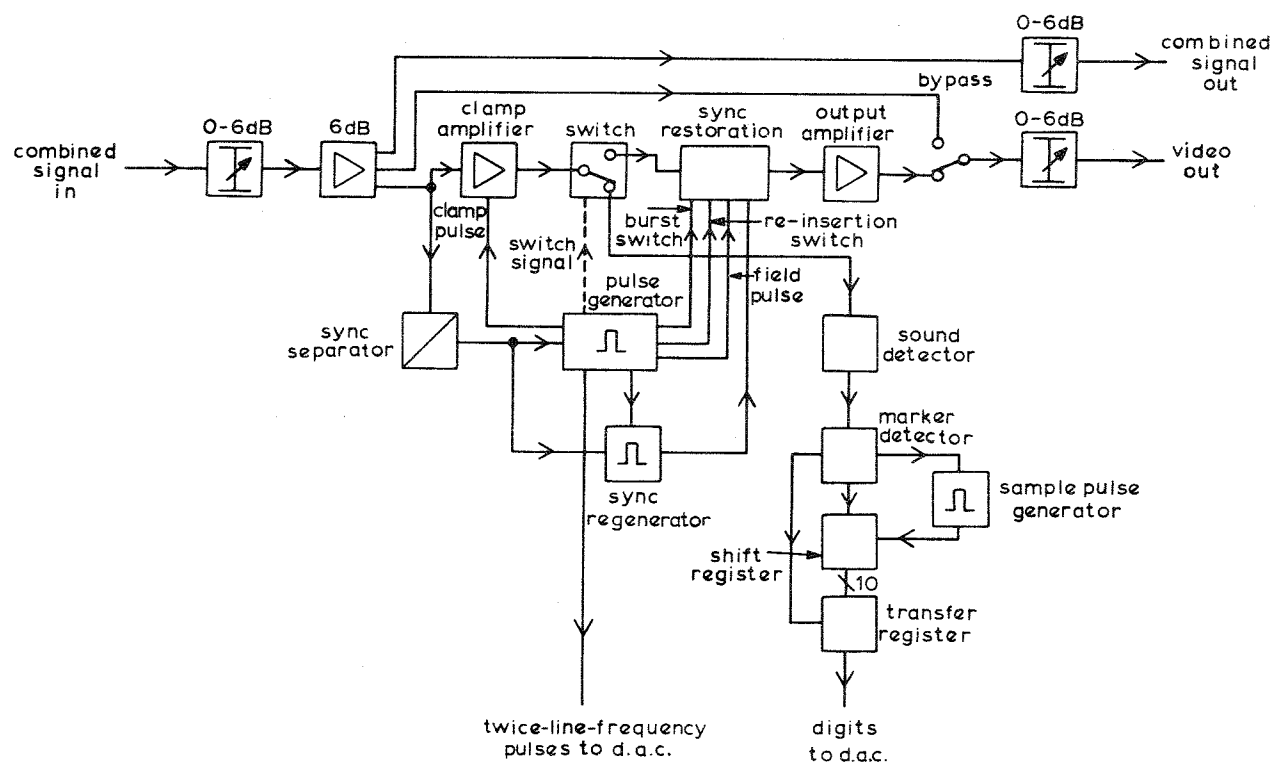


Fig. 6 - Block diagram of separator

Synchronizing pulses separated from the combined sound and video signal trigger all processing within the separator. The sound pulse group is gated from the stabilised combined signal, detected at the centre of the eye height, and sampled by a train of pulses initiated by the marker pulse. The outputs from the sampling process are stored in a two-word store for subsequent interrogation by the digital-to-analogue convertor forming another part of the equipment.⁶

A sync reinsertion signal, comprising the bottom and back edge of syncs and back porch, with the appropriate variations during the field block, is gated into the video signal, thus restoring the video to the standard form with the original leading edge of sync and colour sub-carrier burst preserved.

4.2.2. Input Processing

The sync separator is of special design and employs techniques to inhibit operation during the sound pulse group. A D.C. restorer and clipper operating on the vision signal in a side chain affords crude separation of syncs, the leading edge of which triggers a pulse circuit whose output is then used for inhibiting the sound pulse group. A clamp pulse, also generated from the crudely separated syncs is used for back porch stabilisation of the video signal in the main chain. A further inhibiting action removes the sound group from the stabilised video before final separation of the sync pulses. High performance of separation was achieved in the presence of added noise by using a level detector with a window of 2mV within a sync amplitude of 2.0v, and by accurately steering the detector reference to the half-height point of the sync pulse. The overall delay of the separated syncs was approx 100 ns. This sync separator operated satisfactorily with added distortions equivalent to 2 U.K. reference networks in tandem with noise increased to an unweighted peak signal-to-r.m.s. noise ratio of 27 dB. As in the combiner, inhibit circuits are provided in the pulse generator to prevent separator processes from being initiated until 62 μ s after the preceding sync pulse.

For reasons already stated in Section 3.3 the combined signal is back porch stabilised in a feed-back clamp amplifier with a time constant of approx 10 television lines, the clamp action taking place 8 μ s after the leading edge of syncs, with the appropriate adjustments during the field sync.

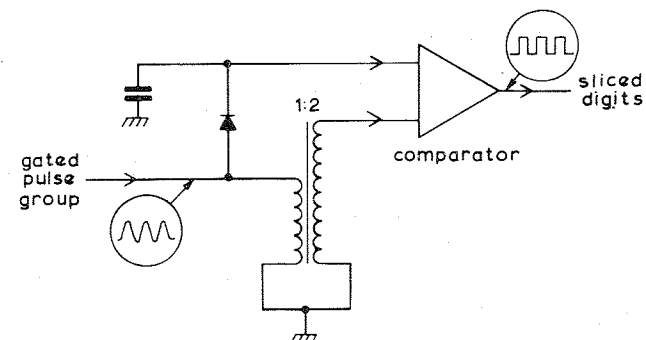


Fig. 7 - Detection of the sound pulse group

4.2.3. Sound Detection

A diode switch gates the video signal to a sync restoration circuit and the pulse group to a sound detection circuit. During the video signal time the level of the signal into the sound detection circuit is held at 0.3 volt below the vision black level, thus restoring the sound pulse waveform to a form having the same reference as in the combiner. In the sound detection unit the sound pulses are detected at the half-height point in a high-gain comparator stage, the reference for the latter being derived by peak rectification of the pulse group. The basic components of this slicing arrangement are shown in Fig. 7: the peak rectified value of the signal on the primary of the 1 : 2 transformer is equal to the half-height value of the signal at the secondary of the transformer.

Subsequent detection of the sound group is dependent on the presence of the marker pulse. If no marker pulse is detected within a certain time interval after the leading edge of syncs, no further detection takes place. If the marker pulse is present, an oscillator is triggered which generates sampling pulses timed to coincide with the centre of each of the 20 sound digits. Fig. 8 shows the detected digits and the sampling pulses.

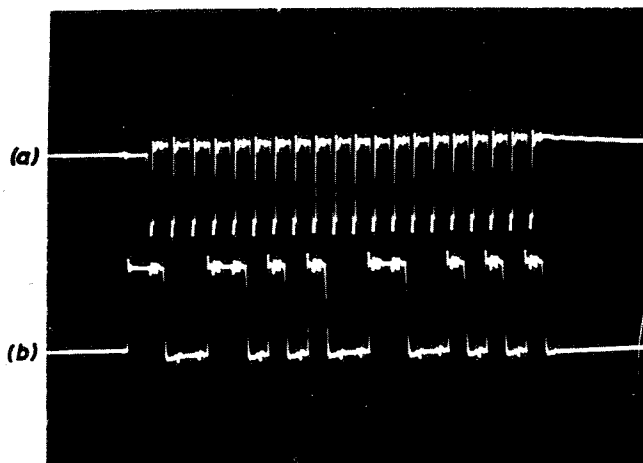


Fig. 8 - Sound pulse group detection

(a) Digit sampling pulses (b) Detected digits

The digit sampling takes place at the serial input of a 20-stage shift register in which the digits are stored. The two 10-bit words appear on alternate stages of the register from which each is extracted at half-line intervals and placed in a 10-stage transfer register forming the output store of this part of the equipment. If no marker pulse appears, clearing of the transfer register is inhibited, and the stored word is repeated. One of the 10-bit words is complemented by selecting the true output of one half of the shift register and the complemented output of the alternate half.

4.2.4. Sync Restoration

The sync re-insertion signal containing the correct width equalising pulses is gated into the video waveform in

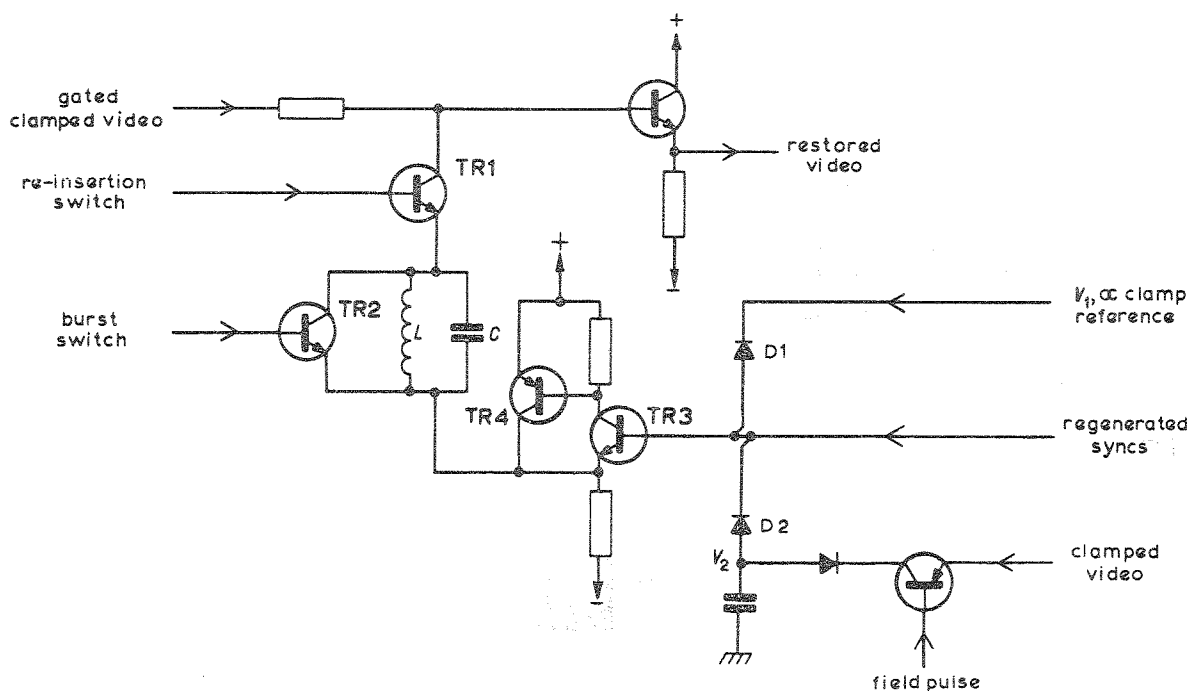


Fig. 9 - Sync restoration

a circuit shown schematically in Fig. 9.

During the sync re-insertion period, switch TR1 connects the video signal to the low-impedance output of the feedback pair TR3 and TR4; the impedance looking forward and backward from this point is such that the signal is attenuated by approximately 50 dB. Applied to the base of TR3 is the regenerated sync waveform which is therefore added to the video signal in place of the original sync. The trap LC prevents the original colour burst from being attenuated, and the switch TR2 short-circuits the trap except during the burst period, thereby preventing components at sub-carrier frequency contained in the original sync back edge from appearing in the output.

The regenerated sync waveform applied to the base of TR3 is clipped by diodes D_1 and D_2 to an amplitude equal to the sync amplitude of the combined signal.

The black level reference potential V_1 is derived from the clamp amplifier, and the bottom of sync reference V_2 from peak rectification of the broad pulses in the combined signal. In the event of the incoming combined signal having no field information, the bottom of syncs is restored to a fixed 0.3v below black level. Fig. 10 is a photograph of the restored video waveform.

4.2.5. Additional Facilities

A 6 dB video distribution amplifier and plug-in

attenuators are provided on the input of the equipment to allow for input levels of between 0.5 volts and 1 volt peak-to-peak. An output of the combined sound-in-vision signal is provided to afford a through connection when the equipment is installed at intermediate points in a distribution network.

A video by-pass facility is provided in case of equipment failure; to facilitate maintenance an input signal is provided when the system is in the by-pass mode.

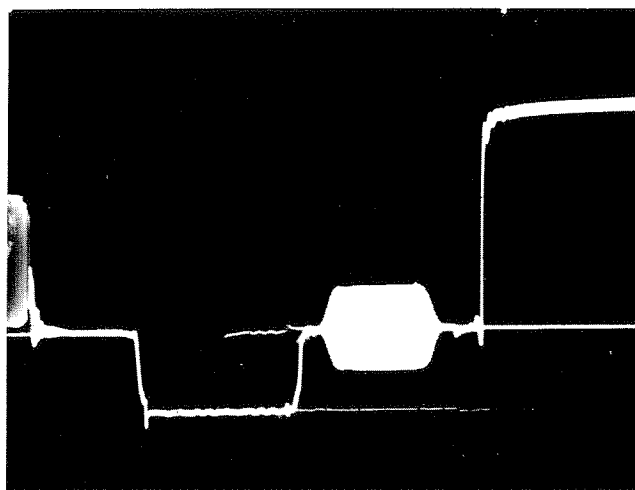


Fig. 10 - Restored vision waveform

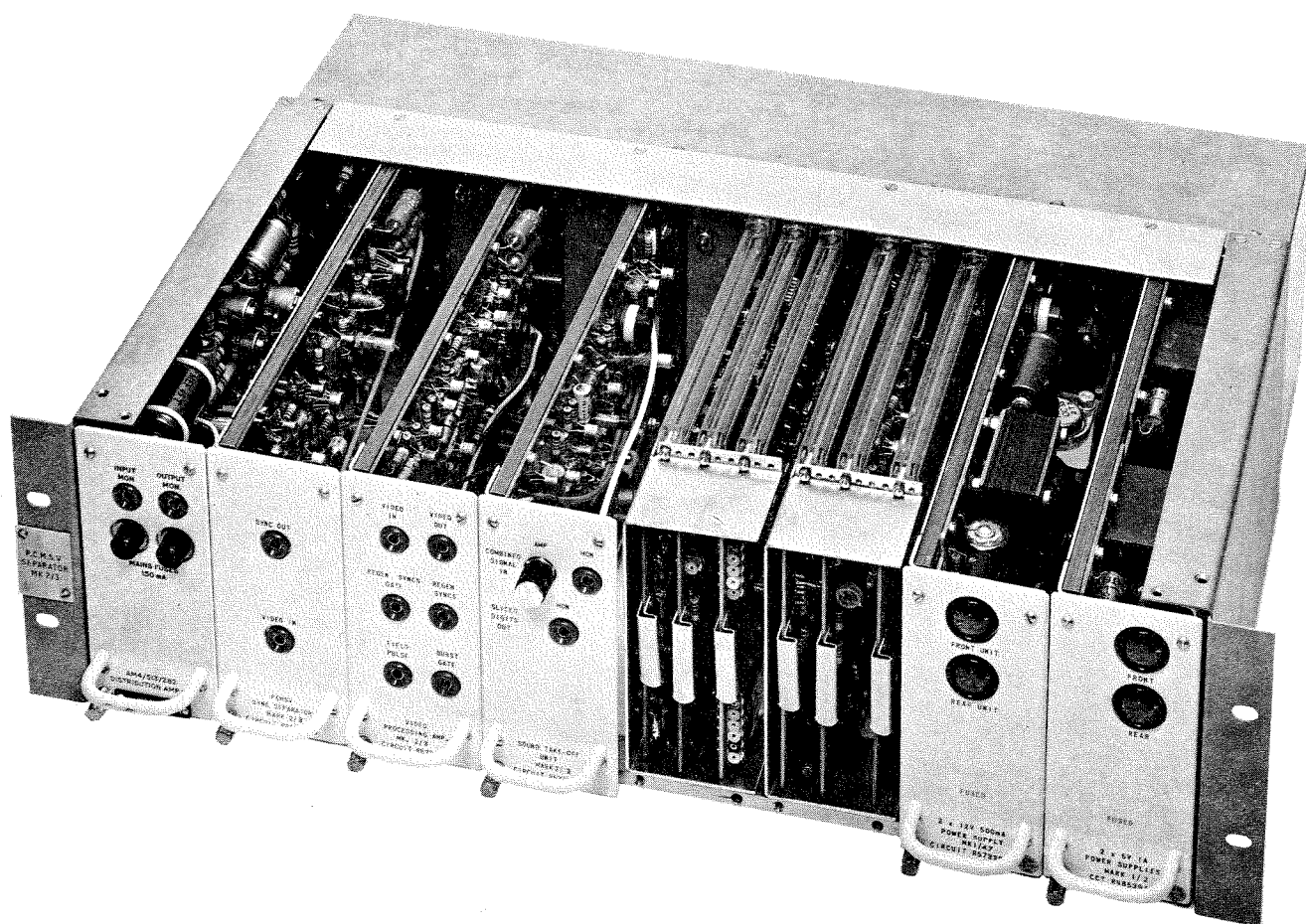


Fig. 11 - Separator

The experimental separator illustrated in Fig. 11 occupies one 19 in. panel.

5. PERFORMANCE

The complete experimental sound-in-syncs equipment was subjected to a number of tests in the laboratory and under service conditions during field trials. The results of these tests have already been published^{9,10,11} and the purpose of this section is to give detailed information on the performance of the combiner and separator alone.

5.1. Video Circuit

5.1.1. Back-to-Back Performance

The overall measured performance of the combiner and separator connected back-to-back was as follows:—

2T Pulse/Bar Ratio	100%
2T Pulse K Rating	<½%
25 μ s Pulse K Rating	<½%
1T Pulse/Bar Ratio	97%
Chrominance/Luminance Inequality	—3%
Chrominance/Luminance Delay Inequality	—4 ns
Chrominance/Luminance Cross Talk	0.25%
Burst Phase Error	1.5°
Differential Phase	2.7°
Differential Gain	5%
Non-linearity	4%
Signal-to-noise Ratio = 85 dB (10 kHz — 5.5 MHz)	pk-pk picture/r.m.s. noise.

The results of chrominance measurements, in particular, differential phase and gain, were considered high and would have to be improved in fully-engineered equipment. The main source of distortion was found to be the video feedback amplifiers in the stabilising circuits; such distortion is not fundamental to the processing necessary in the sound-in-syncs system.

5.1.2. Performance in the Presence of External Distortion

Tests on simulated links indicated that two forms of distortion would in the limit produce disturbances on the separated video signal due to the presence of the sound pulses in the sync period.

Mid-frequency loss, occurring at approximately line frequency and observed as tilt on the 25 μ s bar of a pulse-and-bar signal, gave rise to sound on vision due to perturbations of the back porch by variations in mean level of the pulse group. A degree of distortion corresponding to a K-rating of 8% gave a subjective impairment of grade 2 on the six-point scale; distortion of this magnitude however is on the upper limit of that specified for 2 UK Reference chains in tandem.

Short-term echoes of the order of 5 μ s superimposed a delayed version of the sound pulses on to the back porch, where the clamping action in the separator takes place, and gave rise to sound on vision. A 2% echo gave a subjective impairment of grade 2. Reflections of this form are rare and although specifications⁸ allow 6%, values greater than 2% are not normally tolerated in practice.

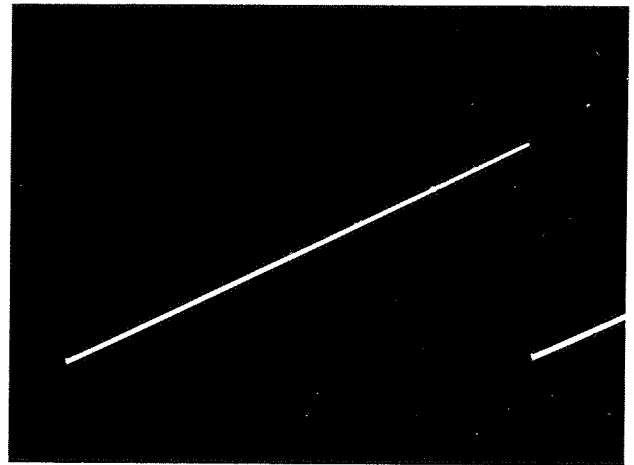
Re-connection of a distribution link following a momentary break resulted in an initial increase of the amplitude of line sync pulses in the reconstituted video signal. Broad pulses were not correspondingly increased and as a result, field roll-over was observed on some picture monitors for a few seconds following the break. The effect was due to the long recovery time of the bottom-of-sync detector used in the experimental equipment; the effect could be obviated in a fully-engineered system.

The temperature stability of the sync re-insertion circuits in the experimental equipment did not meet operational requirements, and some day-to-day adjustment was necessary. It is considered however, that this condition need not arise in a fully engineered system.

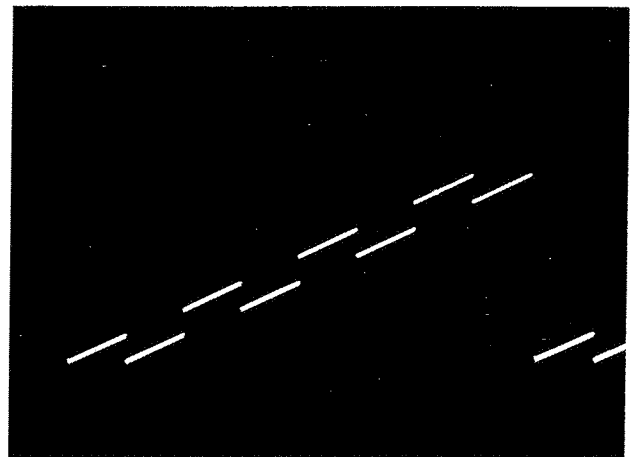
5.2. Sound Circuit

No performance figures are given here for the sound circuit since the function of the combiner and separator is confined to transmitting the sound in digital form. Assuming that the digital transmission is error-free, then the combiner and separator cannot affect the sound circuit performance. For test purposes, however, it was necessary to make use of the a.d.c. and d.a.c. as a source and detector in order to assess the ability of the combiner and separator to transmit the sound digits.

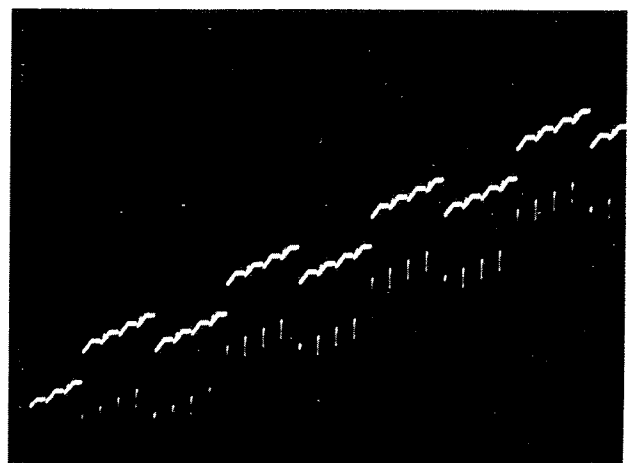
Considerable use was made of the check counter to evaluate performance and Fig. 12 illustrates the usefulness of this device in determining which digits have failed. The waveforms shown are those appearing at the output of the sample-and-hold in the d.a.c.



(a) All digits present



(b) Digit No. 3 missing



(c) Digit No. 8 missing (x40 x and y expansion)

Fig. 12 - Use of check counter to analyse digit faults

5.2.1. Performance in the Presence of External Distortion

The combiner-separator combination transmitted the sound digits satisfactorily with distortions equivalent to 2 UK Reference Chains in tandem under maintenance conditions, plus an additional 12 dB of white noise. The significant parameters of such a link are as follows:—

2T Pulse/Bar Ratio	70%
2T Pulse K Rating	8%K
25 μ s Bar K Rating	8%K
50 Hz Square Wave	8%K
Differential Phase	6°
Differential Gain	12%
Non Linearity	20%
Signal to Noise Ratio	27 dB pk. signal/unweighted r.m.s. noise
Added 50 Hz Hum	40%

The system could tolerate impulsive interference and crosstalk up to a peak amplitude equal to half the eye height, at which point digit errors can occur. Since the eye height is dependent on the amount of other distortions present no absolute limits can be given for the tolerance to impulsive interference.

As in any p.c.m. system, the onset of failure with increasing noise and distortion was sudden and the effect on the sound output catastrophic. Failure was normally due to erroneous sync pulse separation at the receiving terminal rather than digital errors in the p.c.m. system.

5.2.2. Performance during Field Trials

It was discovered during field trials that other forms of disturbance could exist on the distribution links. The performance of the experimental equipment in the presence of these disturbances was rather complex and an understanding of the causes of errors was not apparent until the results of the field trials had been analysed.

Disturbances could be classified under two headings, source faults and link faults.

Source faults such as synchronizing failures, breaks in the signal, malfunctioning of videotape machines and faulty mixer operations did not in the main cause many errors in the reconstituted sound signal. The sound would either continue by means of the reserve syncs, or, if digits were inserted erroneously in the combiner, the separator would detect them. If, however, the faults involved sudden changes in mean video level or loss of syncs without loss of picture — a condition which can occur from some video mixers — then these faults could be emphasised in the combiner feedback clamp amplifiers, and as a result the separator could not function correctly.

Link faults mainly took the form of impulsive interference or breaks in which the combined signal would

suddenly excure to greater than peak white or lower than the bottom of syncs. In the separator this type of fault could cause erroneous sync pulse separation which in turn gated out some part of the video waveform and subsequently interpreted this as a sound pulse group. Moreover, following a break, the sync separator and clamp amplifier took approximately 2 ms to recover, during which time erroneous digit separation could occur.

An analysis of the field trials indicating the frequency of occurrence of source and link faults has already been published.^{10,11}

6. MODIFICATIONS TO EXPERIMENTAL EQUIPMENT

It was decided that if the sound-in-syncs system was to offer an alternative means of sound distribution to the conventional system it would be desirable to make improvements to the sound performance in the presence of source and link faults.

Some form of fault detection was necessary, so that the resulting error signal could operate a sound mute until all the sound detection circuits were restored to normal.

Ideally some form of error-detecting code could be added to the sound pulse group enabling all digit errors to be detected. Although such codes are possible there is insufficient space within the synchronizing pulse period for the number of additional signals that would be necessary to obtain worth-while improvements.

Circuits were devised to examine the complete combined signal for any deviations from the specified characteristics. Long-term breaks and disturbances are found by a sync failure monitor and overswing detectors, the latter indicates when the combined signal exceeds +3 dB on peak vision and bottom of syncs. The outputs of the three detectors are added to form a single error signal which operates a sound mute in the expander⁷ situated in another part of the equipment. Upon restoration of the combined signal the mute remains operative for a further 2.5 ms to allow time for all sound detection circuits to recover.

For shorter-term faults the sound detection is already inhibited if no marker pulse is received. A further fault criterion was based on the signal level at the end of the sound pulse group at a position where a 22nd digit would be placed; sound detection is inhibited if any positive signal appears at this point.

Fig. 13 indicates schematically the essential components of the fault detection system.

A disadvantage of the fault detection described above is that repetitive bursts of heavy impulsive interference will cause the mute to operate, and if the repetition period is less than the 2.5 ms minimum mute time, the sound signal will be continuously muted over the fault period. In a fully-engineered system it will be necessary to control the muting time according to the duration of the fault.

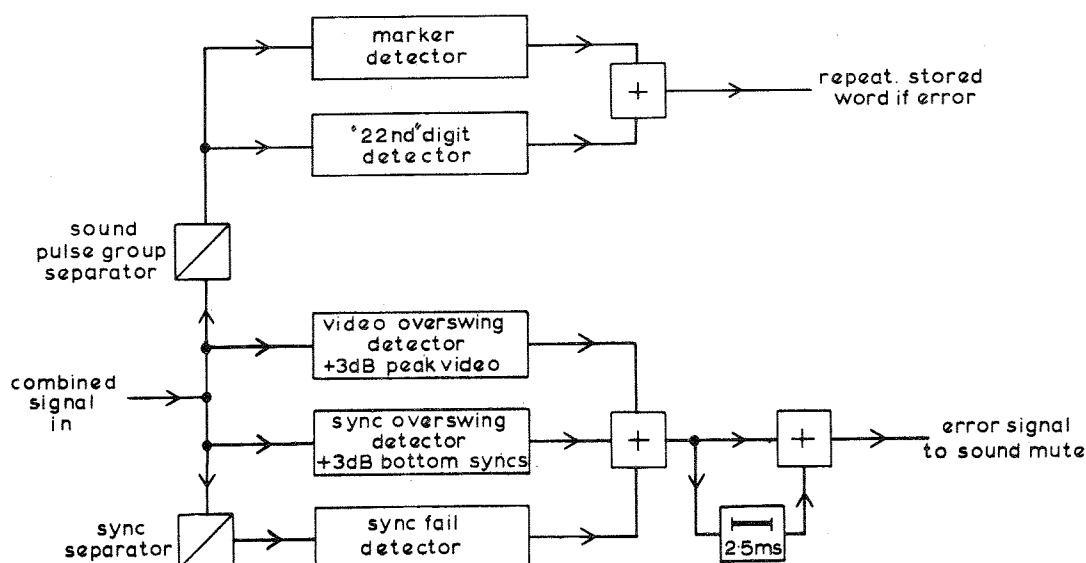


Fig. 13 - Block diagram of modifications to improve robustness of sound circuit

Further field trials of the sound-in-syncs system employing the above modifications indicated that the system offered a sound channel suitable for use in the video distribution network.¹¹

Some other modifications are recommended for adoption in a fully engineered version of the system. Improvements should be made in the video stabilising amplifiers to prevent large deviations from the stabilising potential during fault conditions; this would also assist rapid recovery on restoration of the signal.

In the equipment described the sound and video separation in the receiving terminal is carried out in one function, resulting in a small loss of performance in each path. Separate operations should allow improved performance in the sound and vision paths.

7. CONCLUSIONS

The equipment for the combination and separation of sound and video signals as described in this report has adequately demonstrated the technical feasibility of a sound-in-syncs system. While the experimental apparatus exhibited some technical shortcomings, a fully engineered system using the same system parameters and adopting the improvements indicated should provide a combined transmission system suitable for adoption on the present video distribution networks.

8. REFERENCES

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